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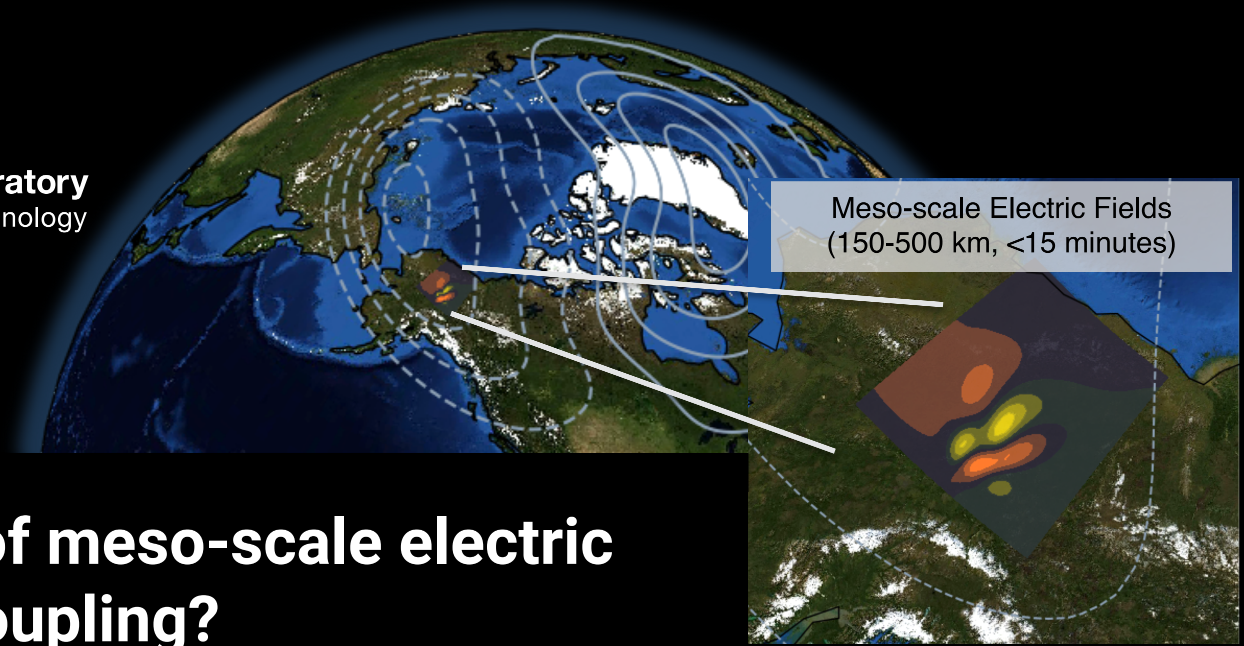

What is the role of meso-scale electric fields in M-I-T Coupling?

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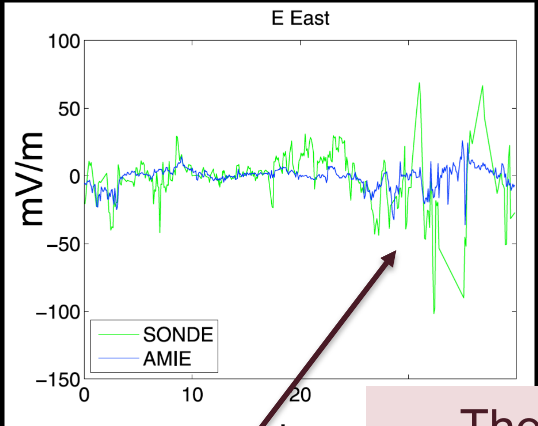
M-I-T Coupling on Meso-Scale



Cosgrove et al., 2009

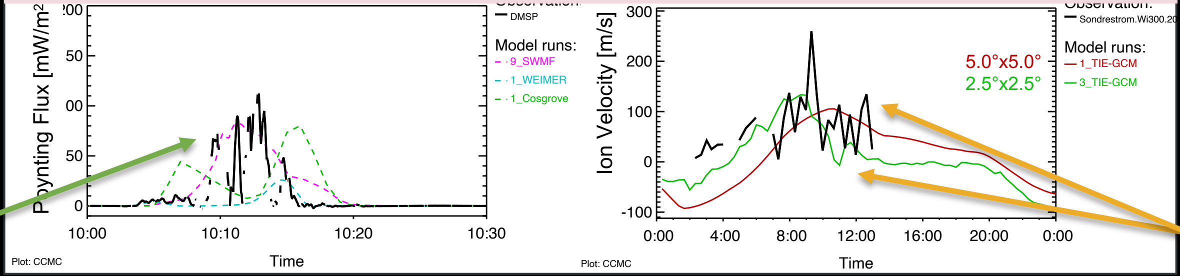
- Global Circulation Models (GCMs) traditionally use empirical models for global estimates of **electric fields and conductivity** and significant work is ongoing to resolve meso-scale structures[1].
- Missing meso-scale electric field variability (temporal + spatial) causes **underestimation of energy input and dissipation in the high-latitude Ionosphere**[2].

t al. (2009); Cousins et al. (2013)
al. (2014); Brinkman et al. (2016)

Assimilative models depend on coverage and resolution of the measurements

There is a need to incorporate dynamic driving through meso-scale structures to further our understanding of the M-I-T system.

Both MHD and empirical models miss the observed variability (~1 min.)



Model results improve on a finer grid, still underestimating the values.

Rastätter, et al., 2016

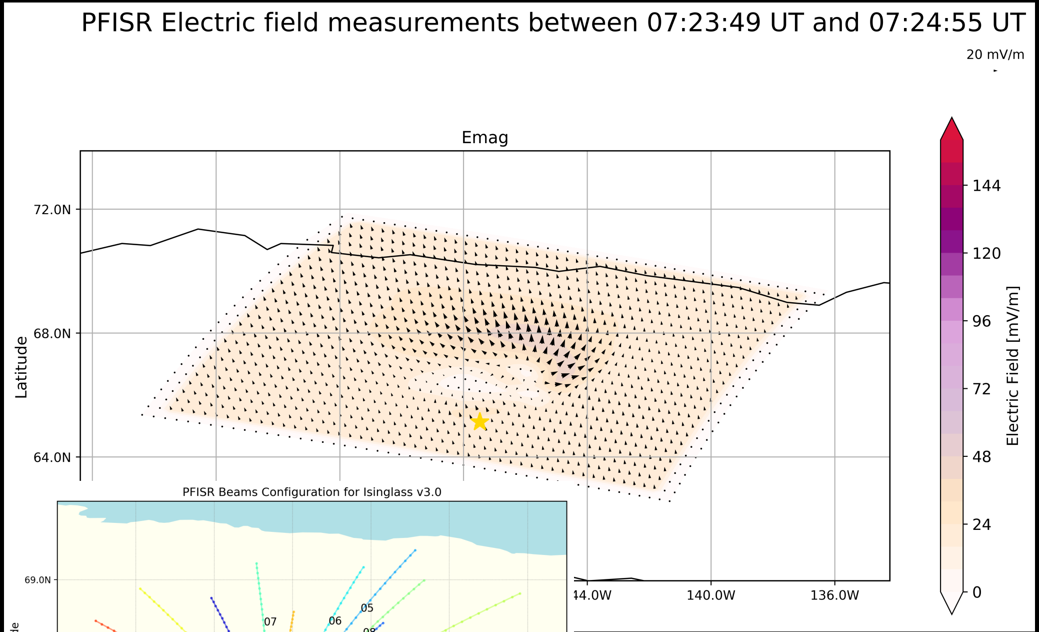
Incorporating meso-scale variability in a GCM

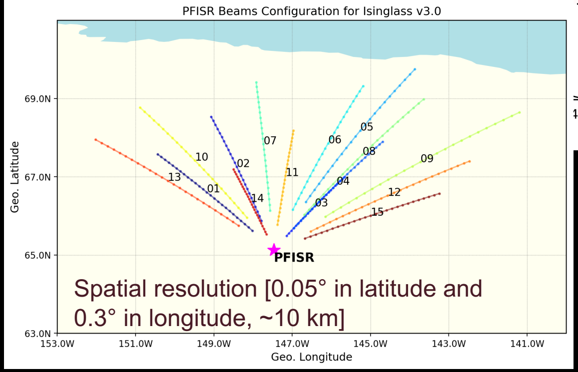
PFISR LOS velocity measurements can be used to derive Electric fields on a 2D grid*.

→ The potential change in longitude (x) and latitude (y) can be calculated:

$$\Delta\phi_x = -\int_{x_1}^{x_2} E_x\, dx\,,\ \Delta\phi_y = -\int_{y_1}^{y_2} E_y\, dy$$

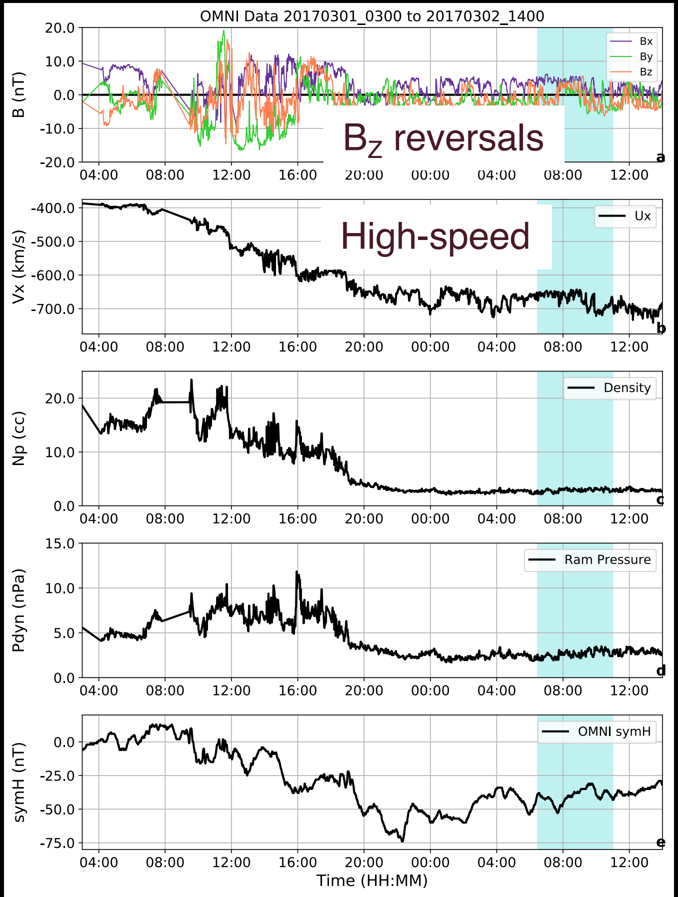
1. Down-sample the x and y components of the electric fields on desired grid. (0.75°x0.75°)
2. Calculate the potentials on the new grid to drive GITM.





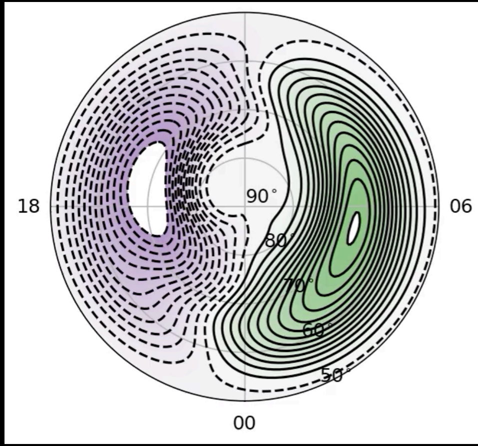
* Procedure requires certain amount of beams, data courtesy of Roger Varney and Ashton Reimer.

March 2, 2017: Solar wind and IMF Conditions

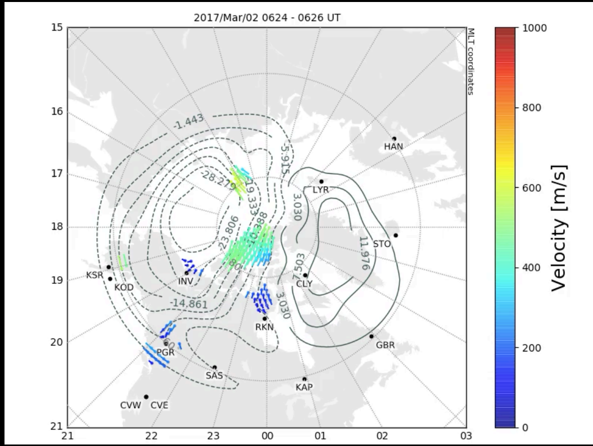


- PFISR was aiding Ionospheric Structuring: In Situ and Groundbased Low Altitude Studies (**ISINGLASS**) Experiment [Clayton et al., 2019]
- Recovery phase of a substorm
- No significant response in Weimer or SuperDARN potentials around 0630 UT.

Weimer Potentials:

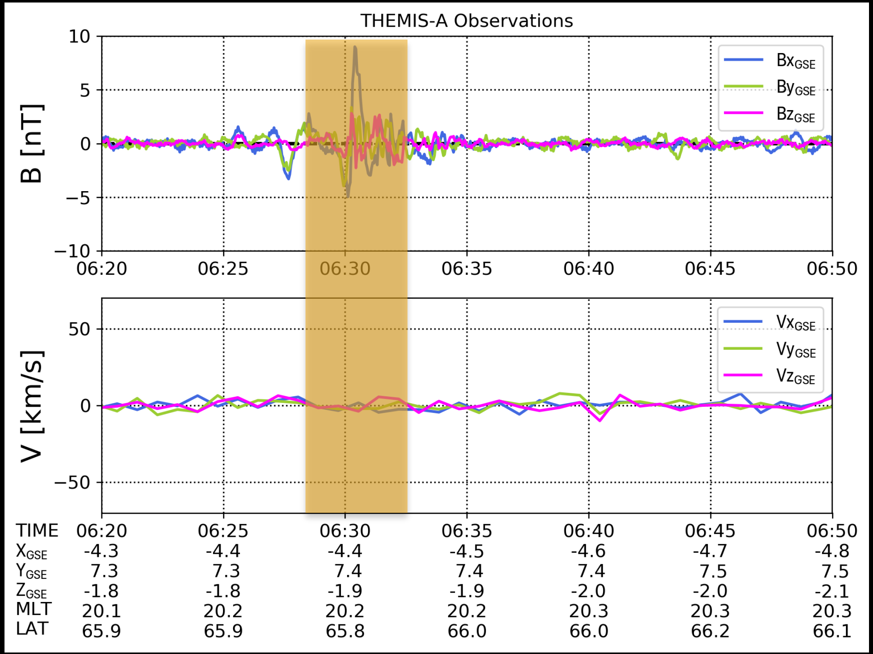


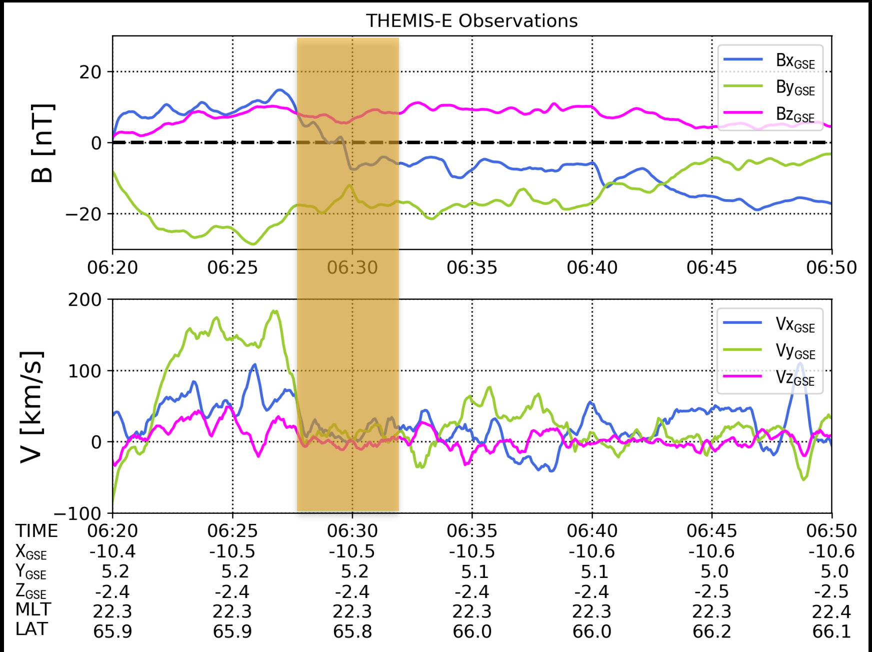
SuperDARN Potentials:



Magnetotail Activity

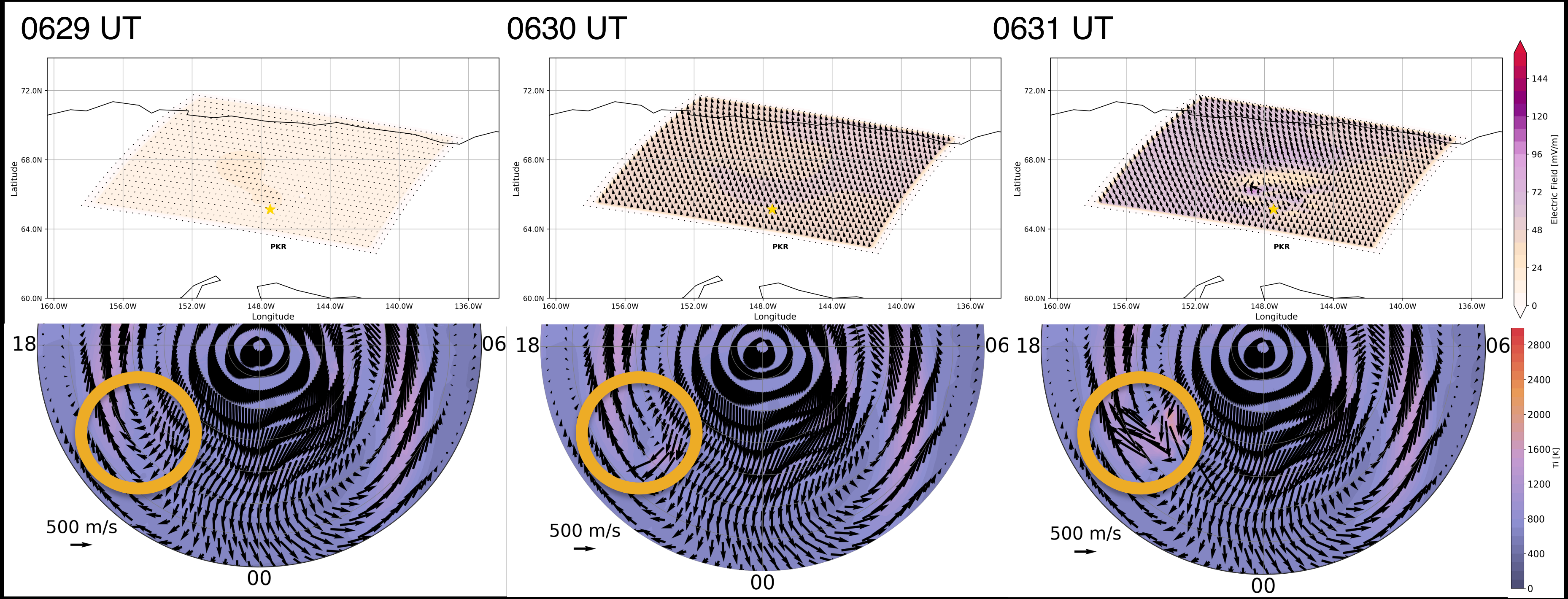
5-min. averaging applied to B and V values.





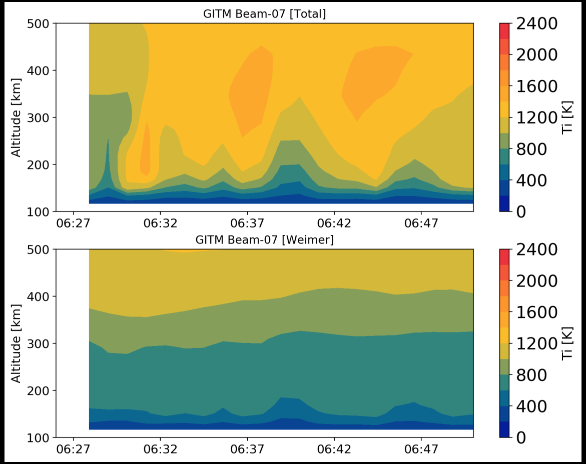
- THEMIS-A B_X measurements show strong fluctuations around 0630 UT.
- Around 0630 UT, THEMIS-E measurements show a B_X reversal.
- Measurements indicate localized ionospheric responses are possible.

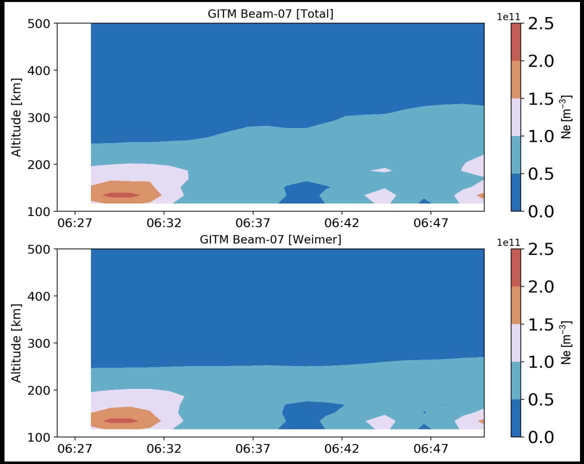
PFISR Electric Field Measurements – GITM Ion Temperature and Convection Simulations

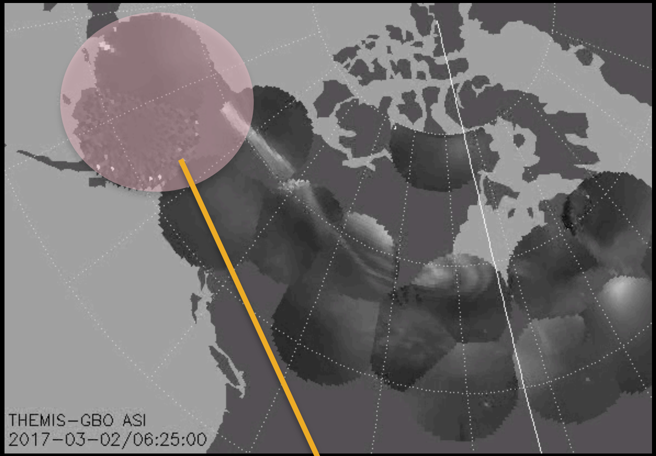


- Ion convection patterns inside PFISR region are enhanced in the westward direction.
- Convection further perturbed at 0631 UT, leading to an ion temperature enhancement of ~ 1000K.

Electron Density Response







THEMIS ASI images show impulsive brightening around 0630 UT

- Ion temperature response is immediate, penetrates to low altitudes.
- Electron density response between Weimer and meso-scale driven run are inseparable, however responses differ later in time.
- Lack of meso-scale particle precipitation in the model → lack of electron density response.
- Working on validation with PFISR (low SNR) and GPS measurements.

Summary

Conclusions:

- We are developing a framework that can utilize **high-latitude local (meso-scale) 2D electric field measurements** as input to run a global I-T model.
- Meso-scale structures are responsible for enhancements in ion temperature and perturbations in ion convection profiles.

Future work:

- Investigate the effects of meso-scale electric fields on the **global energy budget** during active geomagnetic periods.
- Include **a self-consistent treatment** of particle precipitation and electrodynamics for a complete understanding of meso-scale variability.
- Validation Studies: More events, more conjunctions, different sets of drivers and measurements to validate results
- Error and uncertainty quantification

Thank you.

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